A PROPOSAL OF METHODS FOR DETERMINING WATER STABILITY OF EXTRUDED FISH FEED

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PREDLOG METODA ZA ODREĐIVANJE STABILNOSTI U VODI EKSTRUDIRANE HRANE ZA RIBE

Apstrakt

Važan parametar fizičkog kvaliteta ekstrudirane hrane za ribe jeste njena stabilnost u vodi, koja se definiše kao svojstvo peleta uronjenih u vodu da zadrže svoj fizički oblik uz minimalno raspadanje i gubitak nutritivnih komponeneti sve do momenta njenog unosa od strane riba. Stabilnost u vodi hrane je važna za sve akvatične vrste, kako za pastrmke i lososе koji se hrane sporotonućom hranom, tako i naročito za one koje se sporo hrane, kao što su škampi, gde je potrebno da hrana satima u vodi zadrži oblik i sve potrebne hranljive materije. Mala stabilnost hrane u vodi dovodi do slabog rasta riba, neefikasne konverzije i ekonomskih gubitaka, te stoga hrana za ribe mora posedovati visoku stabilnost u vodi kako bi se ribama obezbedila najveća moguća količina hranljivih materija a tako dovelo i do smanjenje troškova proizvodnje.

U ovom radu određena je stabilnost u vodi tri različite grupe hrane za lososе korišćenjem tri metode: statičke metoda, metode mokrog prosejavanja natopljenih peleta i konduktometrijske metode, kao novog pristupa određivanja stabilnosti ekstrudirane hrane za ribe u vodi. Za ispitivanje stabilnosti odabrana su tri uzorka ekstrudirane hrane za lososе tako da poseduju različitu stabilnost u vodi. Cilj istraživanja bio je da se testirajem metoda ispita njihov potencijal za određivanje stabilnosti hrane za ribe, kao i da se proveri međusobna korelacija predloženih metoda.

Na osnovu rezultata ispitivanja, za sve tri korišćene metode primećene su statistički značajne ralike ($p<0,05$) između uzoraka ekstrudirane hrane za lososе. Rezultati dobijeni korišćenjem predloženih metoda pokazali su da je najmanju stabilnost u vodi imao uzorak hrane A, dok je najveću imao uzorak hrane C. Iako se statički metod pokazao kao pogodan

za određivanje maksimalne vrednosti stabilnosti hrane za ribe u vodi, metod mokrog prosejavanja pokazao se kao bolji izbor jer daje jasnije razlike između pojedinačnih uzoraka. Konduktometrijska metoda na osnovu izračunatog koeficijenta varijacije (c_v=0,02%) imala je najveću tačnost od sve tri predložene metode. Primećena je pozitivna korelacija između statičke i metode mokrog prosejavanja (r=0,999; p=0,02), nešto niža korelacija između konduktometrijske i statičke metode (r=0,999; p=0,03), dok je najniža korelacija prisutna između konduktometrijske i metode mokrog prosejavanja (r=0,997; p=0,05), na granici poverenja od 95%. Prednost konduktometrijske metode u odnosu na ostale ispitivane metode ogleda se u mogućnosti direktnog merenja, brzini i osetljivosti.

Ključne reči: stabilnost u vodi, hrana za ribe, ekstrudiranje, prosejavanje, konduktometrija
Keywords: water stability, fish feed, extrusion, sieving, conductometry

INTRODUCTION

Production of commercial fish feed is mostly done by extrusion process, resulting in products high in energy with high physical quality as well good nutritional value. Production conditions and also physiochemical properties of ingredients, affect physical quality of extruded feed (Oehme et al., 2014).

Water stability is an important physical property of feed for aquatic species. It is defined as the retention of the pellet physical integrity with minimal disintegration and nutrient leaching while it is immersed in the water and until it is consumed by animals (Obaldo et al., 2002). Fish feed should have high water stability to prevent increased cost of feeding and to provide the greatest proportion of available nutrients to the cultured animal (Obaldo et al., 2002). For fish that require slow sinking pellet as a feed, such are salmon and trout, water stability may be important to predict the degradation model of feed in the gastrointestinal tract (Sørensen, 2012). Low water stability of extruded feed resulted in oil and water separation and accumulation of free oil in the stomach of rainbow trout, thus induced risk of oil-belching (Baeverfjord et al., 2006; Aas et al., 2011).

The ideal method for determining water stability of aquatic feed should be quick and simple, and should produce practical, accurate and reproducible results is needed (Obaldo et al., 2002). The method should be also able to clearly discriminate between extruded pellets with different water stability (Baeverfjord et al., 2006).

In this work water stability of three different salmon feed samples were investigated by three different methods developed by ourselves: the static water method, wet sieving method, and conductometric method. The aim was to propose and test these novel methods, find a correlation between them and present the potential of the conductometric method for determining water stability of extruded fish feed.

MATERIALS AND METHODS

Three salmon feeds (feed A, feed B and feed C) with different water stability were produced in pilot plant of Feed to Food Center (FINS, Novi Sad, Serbia). Extrusion parameters were changed during production in order to obtain differences in pellet quality. Feed A was produced to have lowest and feed B the highest water stability. Three methods for determi-

ning pellet water stability were defined and tested: static method, wet sieving method and conductometric method. The dry matter (DM) of each feed was determined by drying it at 105°C to constant weight, prior to the water stability tests. All water stability tests were done in duplicate.

Static water method

In the static water method, no pellet or water agitation was involved. Around 25 g of salmon feed pellets were weighed and put in 600 ml glass beaker and 250 ml of distilled water was added. The beaker was covered with aluminum foil and put in the climate chamber (Binder KBF 240, Binder GmbH, Tuttlingen, Germany) where the feed was soaked for 24 hours at 23°C. After soaking, all pellets were transferred on a 2.24 mm sieve and excess of water was gently removed by manually moving the sieve for 20 sec. Pellets were then weighed in a previously dried and weighed glass plate. Soaked pellets were dried in UNB 400 oven (Memmert GmbH, Schwabach, Germany) at 105°C for at least 18 h. After drying, the plate with pellets was again weighed in determining a residual dry matter of the samples. The Water Stability Index (WSI) was calculated as remaining DM weight after soaking divided by initial DM weight of pellets before soaking.

Wet sieving method

The soaking part of this method was the same as for static one and same materials and equipment were used. After soaking pellets were sieved by laboratory sieving device (Retsch AS200 Control, Haan, Germany) and 2.24 mm sieve. The sieving was carried out for 10 min at amplitude of 2, and for the whole sieving duration the pellets were washed directly from the top of the sieve with tap water at maximum flow in order to additionally enhanced disintegration of pellets. Sample drying and results calculations were done in the same manner as it is described above.

Conductometric method

In this method the conductivity of the water solution with immersed pellets was measured during time. In 600 ml glass beaker 25 g of feed pellets were put. After addition of 250 ml, the measuring cell of the Lab960 conductivity meter (SI Analytics, Mainz, Germany) was immediately immersed directly in the middle of the beaker to the point in which the bottom of the cell was at the 100 ml mark. The conductivity measuring device was set to automatically measure and record values of conductivity in the time period of 20 min, during 24 hours. The reference temperature of temperature compensation was preset at 20°C. After 24 h, the conductivity measurement was stopped, and conductivity values and corresponding times were transferred from the measuring device directly to the PC using MultiLabpilot software (WTW, Weilheim, Germany). The obtained conductivity of water after 20 min was chosen as the representative of feed disintegration in distilled water, and it's sign was changed in order to be compared to other two proposed methods

Statistical analysis

One-way analysis of variance (ANOVA) by post-hoc Tukey's HSD test and F-test were used to analyze data at at 95% confidence limit (STATISTICA 12.0, StatSoft Inc., Tulsa, OK, USA). The conductometric method's validity was confirmed, based on correlations with widely used static and wet sieving methods, obtained by correlation analysis.

RESULTS AND DISCUSSION

Water stability results of salmon feeds obtained by static water and wet sieving method as well as water conductivity after 20 min of pellet soaking with negative sign are presented in table 1.

Table 1. Water stability of tested salmon feeds by all three methods

Sample	Static water method (WSI %)	Wet sieving method (WSI %)	Water conductivity after 20 min (μS/cm)
Feed A	87.53±0.01[a]	42.66±0.03[a]	-624.0±0.13[c*]
Feed B	88.99±0.07[b]	54.25±0.53[b]	-361.0±0.09[b]
Feed C	90.00±0.12[c]	61.19±2.09[c]	-151.4±0.08[a]
Variance	1.54	87.58	56075.32
Coeff. of variation (%)	0.13	3.42	0.02

[a,b,c] *Values with the same letter in a column, written in superscript, are not statistically different at the p<0.05 level, 95% confidence limit, according to Tukey's HSD test*
[*] *Negative value is assigned for a comparing and finding of correlation between conductometric and static and wet sieving method*

Feed A had the lowest while the feed C had highest water stability obtained by all three methods (Table 1). The static water method contributed to the significantly higher values of WSI than the wet sieving method that included shaking of pellets. It was in accordance with the results of Obaldo et. al (2002) where the static water method produced the highest DM retention of two shrimp feeds compared with horizontal and vertical shaking methods. As these authors suggested, that static water method can be used for comparing the maximum pellet water stability. The wet sieving method was proved to be a more fitting method for determining water stability as there were more distinctive significant differences between WSIs of all three feed.

Experimental results of conductivity measurements are presented in Figure 1. Feed C had the lowest value of conductivity after 24h, as well as linear nutrient leaching rate. indicating the highest water stability. The superiority of conductivity measurement compared to other methods can be observed from Table 1, where conductivity data span a much larger range of values (also shown with larger variance) compared to static and wet sieving method, but still, the accuracy of conductivity measurement remains much higher compared to the other fish feed water stability tests (according to the coefficient of variability, which is calculated to be 0.02%).

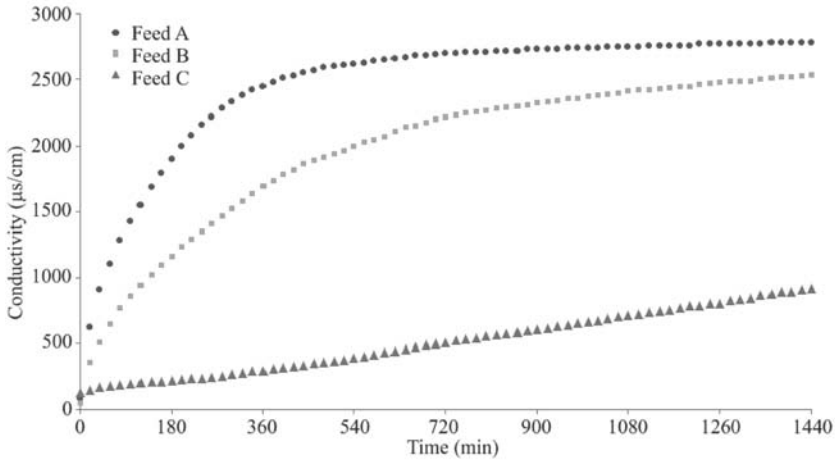

Figure 1. Water conductivity during 24 h soaking of tested salmon feeds

The possibility of direct measurement, high resolution screening of results as well as rapidness and sensitivity are certain advantages of the conductometric approach over other two proposed methods Statistically significant difference ($p<0.05$) has been found in all samples, at significance level (Table 1). This novel assay has been validated through correlation analysis with other two water stability tests employed in this study (Table 2).

Table 2. Correlation coefficients between static water and wet sieving method and conductivity measurement of water

	Wet sieving method	Conductivity of water after 20 min
Static water method	r=0.999* p=0.02	r=0.999* p=0.03
Wet sieving method		r=0.997* p=0.05

* *Significant at 0.05 level*

CONCLUSION

The results of water stability of tested salmon feed obtained by all three proposed methods, significantly differed within the specific method, thus proving that methods can be successfully used for relative comparison water stability between different feeds. The static water method was shown to be suitable for determining maximum water stability of feed, while wet sieving method was proven to be suitable for showing differences in water stability between various samples. Positive correlations between the results of conductometric method and the other two applied methods were obtained. The results indicated that con-

ductometric method is accurate, rapid and simple method which can be successfully used for determining water stability of salmon feed.

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